Understanding Potential Water Heater Scald Hazards

A White Paper

Developed by the American Society of Sanitary Engineering Scald Awareness Task Group

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Section 1

Executive Summary

The American Society of Sanitary Engineering (ASSE) Scald Awareness Task Group was formed to educate and give guidance to the general public and plumbing industry on scalding hazards associated with hot water at the point of use. This White Paper focuses on one aspect of the hot water delivery system: the thermostat setting at the water heater. Improper design and use of hot water delivery systems can lead to scalding and other health and safety related effects.

There is a general misconception that the water heater thermostatic control is capable of delivering a constant, safe water temperature. Temperatures at the point of use over 120 degrees F (49 degrees C) are considered a hazard. Without further temperature controlling downstream of the outlet of the water heater, the potential to experience dangerous scalding water temperatures at the point of use increases greatly.

There are confirmed instances of health hazards when storing domestic hot water for human use and/or contact at temperatures known to sustain growth of harmful bacteria. The storage temperature in a tank type water heater should be at least 135 to 140 degrees F (57 to 60 degrees C) to minimize the growth of harmful bacteria normally present in the water.[1]

Scald injuries can be prevented by following these guidelines:

- **Be Aware:** Understand the risks of scalding.
- **Be Proactive:** Always test the water to ensure a safe temperature.
- **Be Responsible:** Have a qualified service person or plumbing engineer make an assessment of your potable hot water heating and delivery system to see if one or more of these devices are applicable:
    - Temperature actuated mixing valve
    - Automatic compensating mixing valve
    - Temperature limiting device

Scald injuries caused by excessive hot water temperatures at the point of use are minimized by following the recommendations provided in this White Paper.

[1] *American Society of Plumbing Engineers Position paper, May 6, 1989, and ASHRAE Guideline 12-2000, para. 4.1.6*

Purpose

The ASSE Scald Awareness Task Group was formed to educate and give guidance to the general public and plumbing industry on the many ways that someone can be exposed to the potential scalding hazards associated with domestic hot water at the point of use.

This White Paper focuses on one way that this exposure can occur: relying only on the thermostat setting at the water heater as the primary water temperature control at the point of use. **Many people have the misconception that the water heater thermostatic control is capable of delivering a constant, consistent water temperature.** This paper addresses why this misconception can create a false sense of security, and more importantly, details how scalding and thermal shock can be avoided and how to control the final point of use temperature.

The majority of scald injuries caused by excessive hot water temperatures at the points of use should be eliminated by using the recommendations in *Section 6 - The Solutions*.

Recommendations for lowering the water heater thermostatic control setting have reduced the risk of scald injuries, but have not **fully** solved the problem.[2]

[2] *Tap Water Scald Prevention: Its Time for a Worldwide Effort; Katcher ML, Injury Prevention 1998:4;167-169*

Section 3

The Problem

Storage type water heaters have been used in domestic applications since the early 1900s. Since this time, water heater technology has continued to improve to the present day and is a reliable source of hot water in almost every home. However, as a large water storage device, there are technology limits to the precision of water temperature control. Water heaters alone cannot accurately control the hot water temperature at the point-of-use. For example, without specific technical knowledge of how the water heater operates and failure to review operating instructions, the specifier, installer and consumer may assume that the water heater can control the water temperature with the same precision that the thermostat for the heating and air conditioning system controls the temperature in the home. This misconception has led many users and operators to set the water heater thermostatic control at 120 degrees F (49 degrees C) and incorrectly assume that the water temperature will not exceed this value. However, temperatures over 120 degrees F (49 degrees C) at the points of use are considered a hazard, with extremely higher temperatures causing serious second and third-degree scald burns upon contact with adult skin.

Since the water heater thermostatic control is typically located at the bottom of the water heater, it does not sense the water temperature at the upper outlet of the water heater. Without further temperature controlling downstream of the outlet of the water heater, there is potential to experience hot water temperatures at the point of use that pose a scald hazard. For this purpose, most water heater manufacturers and various plumbing codes[3] require that the **water heater thermostatic control should never be used to control the final temperature of the water to the point of use.**

[3] *International Plumbing Code; International Residential Code; Uniform Plumbing Code*

Examples of the Problem

EXAMPLE 1:

It is well known and documented that you cannot control the upper outlet temperature of a water heater with its manually adjustable thermostatic control. Just physically turning down the water heater thermostatic control will not eliminate the risk of scalding temperatures since the water heater thermostatic control is not accurate enough to prevent these scalding temperatures. Also, the water heater thermostatic control does not address pressure imbalances in the hot and/or cold water distribution system, which have been known to cause thermal shock when a non-compensating type shower or tub/shower combination valve has been installed and/or replaced. Most model plumbing codes require automatic compensating type shower valves that comply with ASSE 1016/ASME A112.1016/CSA B125.16, which have pressure, temperature, or pressure and temperature compensating elements and a maximum temperature limiting stop, which can limit the hot water temperature coming from the shower valve to prevent scalding in showers and/or tub/shower combinations. These model codes **also prohibit** the water heater thermostatic control from being used as the final control of the water temperature. Unfortunately, there are some jurisdictions which allow exceptions to these code requirements. Such an exception will allow anyone to install a non-automatic compensating type shower or tub/shower combination valve, which cannot and will not prevent thermal shock or scalding.

EXAMPLE 2:

A person hears about scalding dangers associated with water heaters on a handy man talk show where the host recommends turning down the water heater thermostatic control to prevent scalding. This person then decides to set the water heater thermostatic control at the 120 degrees F (49 degrees C) setting as recommended. It is possible for the household to experience multiple intermittent short draws of hot water usage, whereby cold water gets introduced at the bottom of the water heater and then causes the thermostatic control to sense the cold water, which turns the burner on. When this intermittent usage occurs within a relatively short time period, it causes overheating of the upper water at the top of the heater. This is referred to as thermal layering or stacking or stratification. This thermal layering can result in hot water temperatures in excess of 140 degrees F (60 degrees C) at the top of storage type water heaters. When the water heater is in a stacking condition and where there is extremely hot water at the top of the water heater, a person gets into the shower and physically adjusts a non-compensating shower valve to a comfortable bathing temperature. Unexpectedly, the temperature could suddenly spike to a scalding temperature when someone else in the house uses cold water while the shower is running. Water at an extreme scalding temperature may cause irreversible third-degree burn injuries instantly upon contact with the skin. It is for this reason the model plumbing codes have added language mandating that the thermostatic control on the water heater not be used as the final temperature control to prevent scalding and thermal shock. A compensating type shower or tub/shower valve that meets the requirements of ASSE 1016/ASME A112.1016/CSA B125.163[4] should be installed at the point of use to prevent the potential of thermal shock and scalding and/or a master thermostatic mixing valve conforming to ASSE 1017-2009[5] or CSA B125.3-11[6] should be installed at the water heater to limit the hot water temperature to a safe delivery temperature at the fixture.

[4] *ASSE 1016-2011/ASME A112.1016-2011/CSA B125.16-11, Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations.*
[5] *ASSE 1017-2009, Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems*
[6] *CSA B125.3-11, Plumbing Fittings*

Health Related Concerns

There are instances of confirmed health hazards from storing domestic hot water for human use and/or contact purposes at temperatures known to sustain growth of certain harmful bacteria. This section is intended to provide helpful information regarding the potential dangers of stored water temperatures that have been directly associated with the growth of these harmful bacteria.

Legionella pneumophilia bacteria is the causative agent of Legionellosis, or Legionnaires Disease. Legionella bacteria are commonly found in potable water supplies and they can multiply in warm, nutrient-rich domestic hot water systems, hot tubs, cooling towers, fountains, swimming pools and similar warm water environments. The Legionella bacteria can spread to humans when breathed in. Aerosolized water droplets containing the bacteria can be transmitted through a variety of sources to make their way into the warm, wet linings of the lungs, where the bacteria grow and multiply. This transmission can be from breathing in the mist from a showerhead or cooling tower, the steam from a hot tub, or by choking or aspirating while drinking water that contains the bacteria.

"Of the approximately 2.4 million cases of pneumonia that are diagnosed each year in the United States, about 18,000 (less than one percent) are confirmed as Legionnaires' Disease and up to 600,000 cases of Legionnaires' Disease are misdiagnosed as pneumonia because the hospitals do not perform the tests for Legionella."[7]

The American Society of Plumbing Engineers (ASPE), in a position paper approved by their Board of Directors on May 6, 1989, recommends that the outlet temperature at a storage type water heater be a minimum of 135 degrees F (57 degrees C) to a maximum of 140 degrees F (60 degrees C) to prevent the growth of legionella bacteria normally present in the water ***(See Section 8. Figure 1 - Water Temperature Effects on Legionella Bacteria)***. At this stored water temperature, the risks of scalding are prevalent and measures need to be taken to ensure that the point of use temperature is delivered low enough to prevent injuries due to scalding.

Other portions of the water delivery system, besides the water heater, may contribute to the growth of Legionella bacteria. There is a direct conflict between the safe delivery temperature of hot water to the points of use and the hot water temperature needed to minimize the growth of Legionella bacteria. Please refer to ***Section 6 – Solutions to the Problem*** for additional information.

[7] *http://www.LegionellaPrevention.org*

Solutions to the Problem

With the facts established as to the water temperature that begins to cause scald injuries, the water temperature required to eradicate unhealthy bacteria and the conditions surrounding accidental scald injuries, the problems are clearly stated and straightforward. Those most susceptible to accidental scald injuries are dependents that need, but may not receive, full time assistance or supervision during normal washing or bathing practices. Good News: thanks to advancements in water tempering and limiting technologies, along with simple common sense practices and devices that are installed and maintained properly, scald injuries can be prevented by following these guidelines:

- **Be Aware** – All responsible individuals in the household must understand the risk of scalding and the facts presented in this paper associated with how scald accidents occur. This is a major first step in reducing scalding and thermal shock incidents.

- **Be Proactive** – Always test the water to ensure a safe temperature before allowing yourself, children and those adults that need assistance to step into a shower or full bathtub. A safe temperature depends on age, skin condition and health of the bather. Caution: It should be noted that even if you test the water and it is found to be a safe temperature, you can still be instantly scalded if there is a non-compensating type shower valve installed in the shower and there is a pressure disturbance in the water supply caused by someone else in the building using cold water during the shower.

- **Be Responsible** – If there are dependents in your household that require supervision during showering or bathing, the risk for a scald accident increases. Have a qualified service person or plumbing engineer, knowledgeable about the latest technologies in temperature actuated mixing valves, automatic compensating type mixing valves and water temperature limiting devices, make an assessment of your domestic hot water heating and delivery system to see if one or more of these devices are applicable to your needs to minimize the risk of scalding at the point of use in your household.

    Temperature Actuated Mixing Valve[8] – A device installed at or near the outlet of the water heater appliance that automatically tempers the hot water to a preset temperature that is safe for human contact before it reaches the point of use, regardless of the water heater thermostat setting.

    Automatic Compensating Mixing Valve[9] – A device installed at the shower or tub that automatically blends the hot water supply with sufficient cold water to deliver water temperature to the shower head or tub spigot that is safe for human contact, regardless of the positions of the manual valve settings.

    Temperature Limiting Device[10] – A device installed at lavatories, sinks, bathtubs, etc. that prevents the water temperature from exceeding a preset temperature.

[8] *Temperature actuated mixing valves must conform to ASSE 1017-2009, Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems, or CSA B125.3-11, Plumbing Fittings.*

[9] *Automatic compensating mixing valves must conform to ASSE 1016-2011/ASME A112.1016-2011/CSA B125.16-11, Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations.*

[10] *Temperature limiting devices must conform to ASSE 1070-2004, Performance Requirements for Water Temperature Limiting Devices, or CSA B125.3-11, Plumbing Fittings.*

Definitions

Automatic Compensating Valve — A water-mixing valve that is supplied with hot and cold water, and that provides a means of automatically maintaining the water temperature selected for an outlet.
Note: Automatic compensating valves are used to reduce the risk of scalding and thermal shock.

Combination Pressure-Balancing and Thermostatic Compensating Valve (Type T/P) — A compensating valve that senses inlet supply hot and cold water pressures before mixing, senses the water temperature at the outlet, and compensates for pressure and thermal variations to maintain the water temperature at the outlet.

Pressure-Balancing Compensating Valve (Type P) — A compensating valve that senses inlet supply hot and cold water pressures and compensates for variations in the inlet supply pressures to maintain the water temperature at the outlet.

Thermostatic Compensating Valve (Type T) — A compensating valve that senses the water temperature at the outlet and compensates for thermal variations to maintain the water temperature at the outlet.

BURNS:

First-Degree Burn — First-degree burns are red and very sensitive to touch, and the skin will appear bleached when light pressure is applied. First-degree burns involve minimal tissue damage which involves the epidermis (skin surface). These burns affect the outer-layer of skin, causing pain, redness and swelling. Sunburn is a good example of a first-degree burn.

Second-Degree Burn — Second-degree burns affect both the outer-layer (epidermis) and the underlying layer of skin (dermis), causing redness, pain, swelling and blisters. These burns often affect sweat glands and hair follicles. If a deep second-degree burn is not properly treated, swelling and decreased blood flow in the tissue can result in the burn becoming a third-degree burn and possible infections.

Third-Degree Burn — Third-degree burns affect the epidermis, dermis and hypodermis, which generally cause charring of skin or a translucent white color, with coagulated vessels visible just below the skin surface. These burn areas may be numb, however, the person may complain of pain. This pain is usually caused by second-degree burns. Healing from third-degree burns is very slow due the skin tissue and structures being destroyed. Third-degree burns usually result in extensive scarring.

Non-Automatic Compensating Valve — A water-mixing valve (one, two or three handle) that is supplied with hot and cold water, and that does **not** provide a means of automatically maintaining the water temperature selected for an outlet. This type of mixing valve also does not have maximum temperature limit stops to limit the mixed water outlet temperature.

Point of Use – The final outlet of the water supply system just prior to discharge for use.

Scalding – Thermal injuries caused by exposure to hot water. The severity of a scald burn injury depends on both the hot water temperature and the length of exposure to a given hot water temperature.

Stacking, Thermal Layering or Stratification – Layers of varying temperature hot water in the storage tank, created by the intermittent actuation of the water heater thermostatic control caused by short and frequent draws of hot water from the storage tank at the point of use.

Thermal Shock – A significant sudden change in temperature from hot to cold, cold to hot, or hot to hotter that causes a bather to violently react, which generally leads to a slip and/or fall injury.

Water Heater Thermostatic Control – A device that senses changes in the temperature of the stored water and automatically actuates the heating source to maintain the selected water temperature between predetermined limits.

Tables, Graphs & Graphics

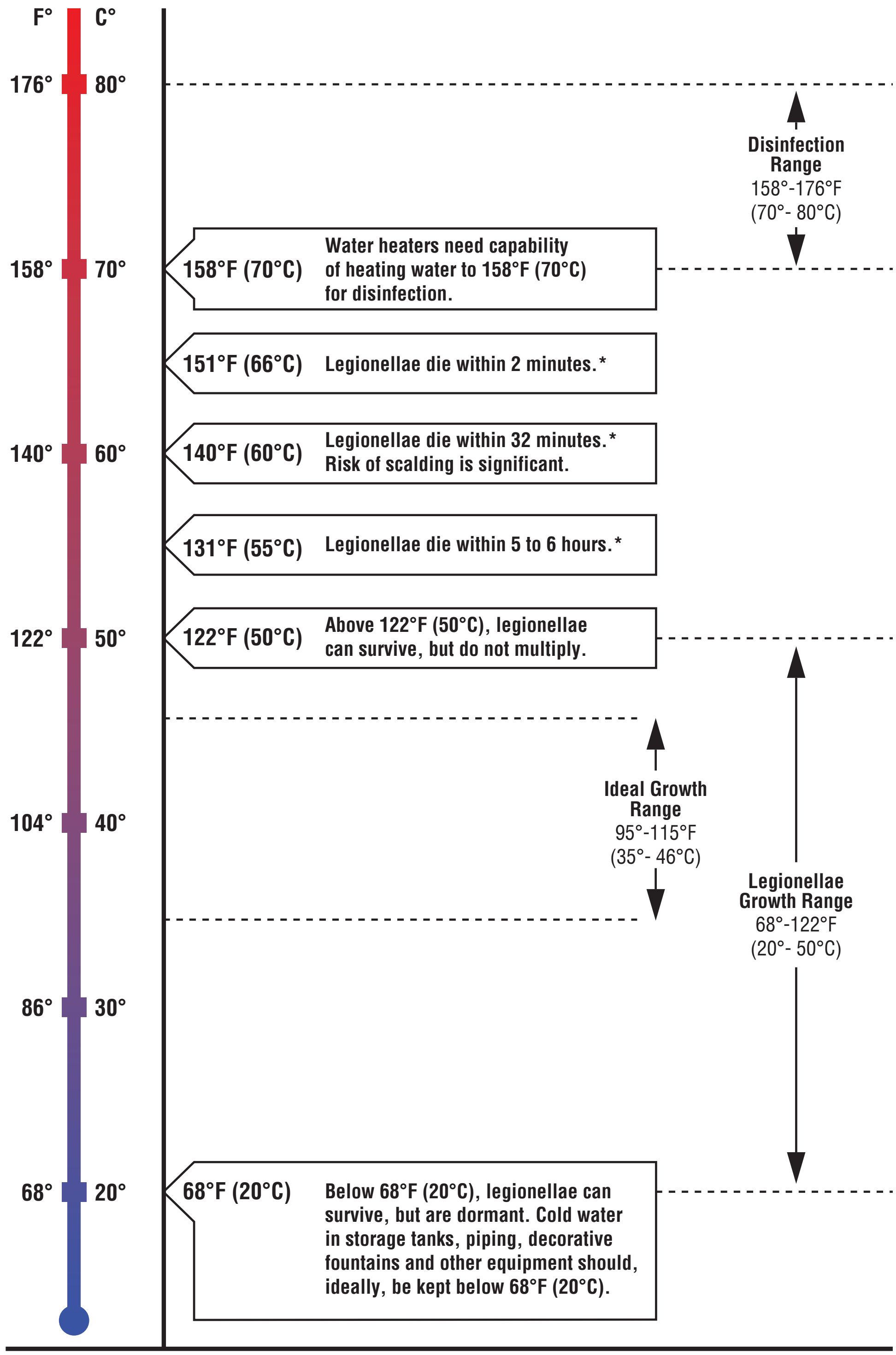
Scald burns and fall injuries due to sudden temperature changes, known as thermal shock, can and do happen. Young children, the elderly and people with disabilities are more susceptible to injuries from hot water. Many domestic water scald burns happen in the home from exposure to extreme hot water in the kitchen or bathrooms, with a number of them coming from faucets (point of use). The severity of these injuries is dependent on the temperature of the hot water and the amount of time of the exposure, as shown in Table 1 below.

Table 1 – Estimated Time & Temperature Effects on Adult Skin

WATER TEMPERATURE		TIME FOR A MILD	TIME FOR PERMANENT
Deg. F	Deg. C	First Degree Burn	Second Degree Burns
110	43	Normal Hot Shower	
116	47	Pain Threshold Approx	
116	47	35 Minutes	45 Minutes
120	49	3 Minutes	9 Minutes
122	50	1 Minute	5 Minutes
126	52	30 Seconds	90 Seconds
131	55	5 Seconds	25 Seconds
140	60	2 Seconds	5 Seconds
159	65	1 Second	2 Seconds
154	68	Instantaneous	1 Second

SOURCE: Moritz and Henriques, “Study of Thermal Injury: II”
American Journal of Pathology 1947; 23: 695-720
Technical Bulletin 34, US Government Memorandum, C.P.S.C.

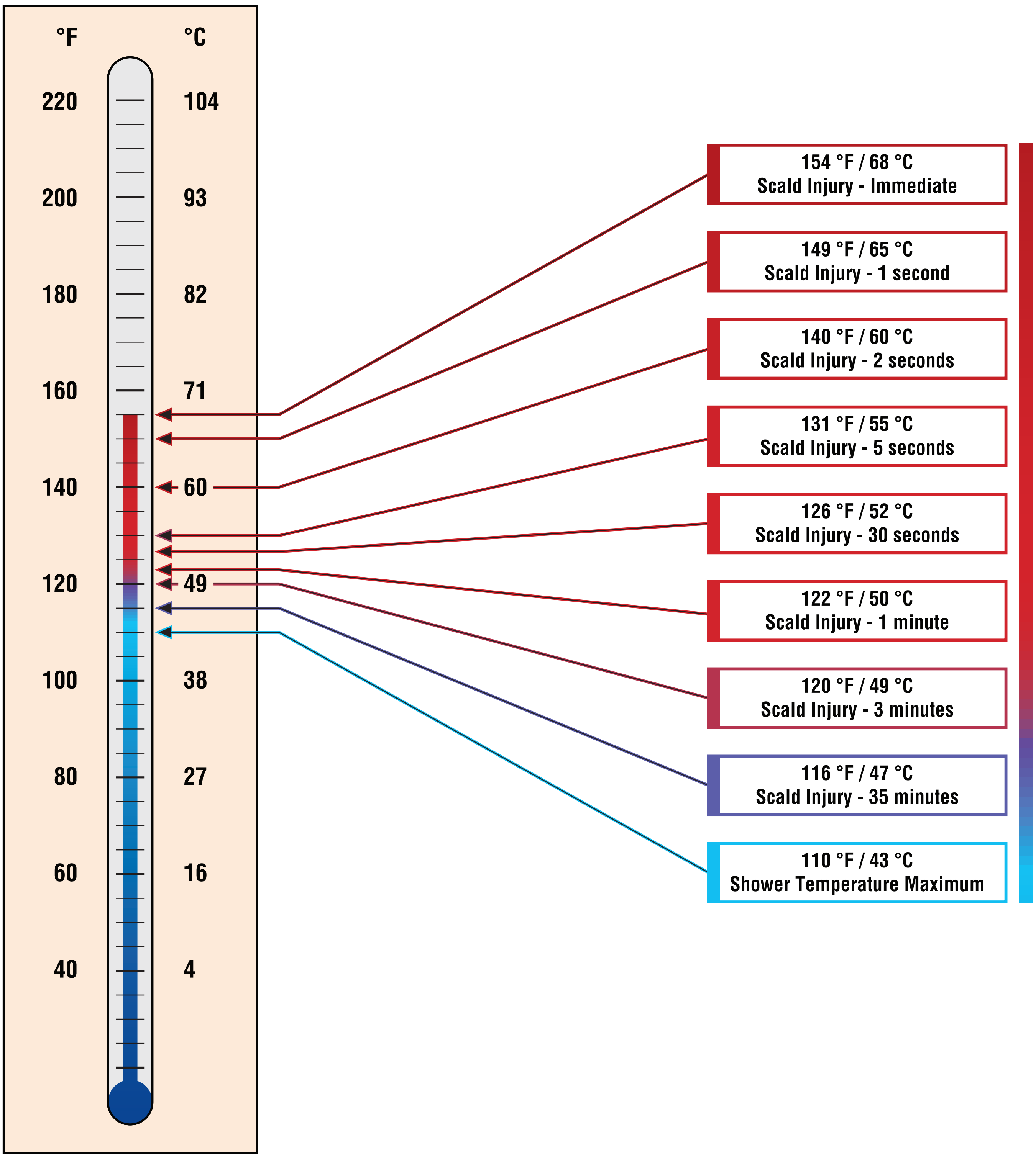
Figure 1 – Water Temperature Effects on Legionellae Bacteria



* Sterilization value assuming a maximum concentration of 1,000 cfu/ml

FIGURE 1. Diagram showing how several legionella species, including legionella pneumophila, respond to water temperatures in a laboratory setting. In an actual hot-water system, legionellae may multiply at temperatures well above 122°F because of scale, biofilm and other complexities. ***(Excerpted from Matthew Freije's book, Legionellae Control in Health Care Facilities: A Guide for Minimizing Risk, with permission from the publisher, HC Info (www.hcinfo.com))***

Figure 2 – Water Temperature vs Scald Potential



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A total of 36 industry professionals contributed both time and expertise to the development of this paper; some requested to not have their names included. The group included: manufacturers, engineers, industry associations, master plumbers, general interest members, inspectors and labor representatives.

The American Society of Sanitary Engineering expresses its sincerest gratitude to all of the members of the Scald Awareness Task Group for their dedication and contributions to this project.

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